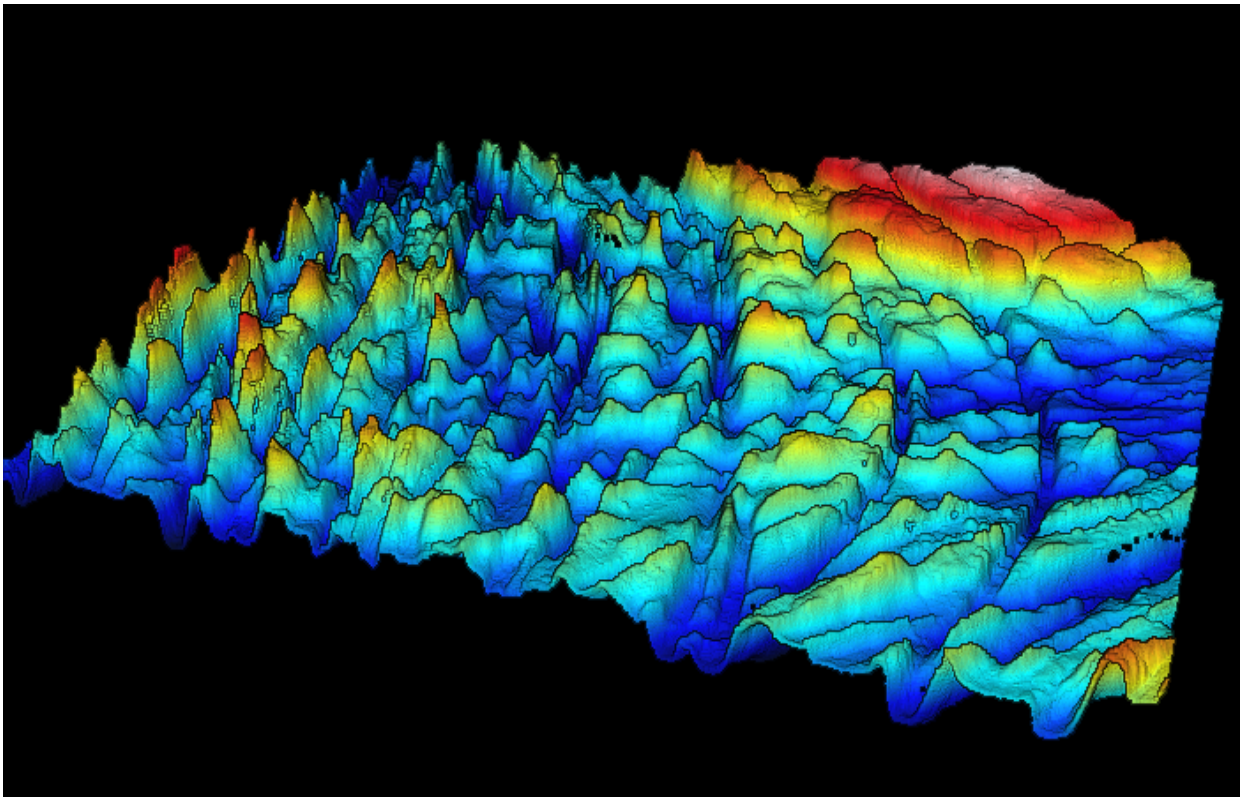
Document title:

H6.2B FILTERING AND ESTIMATION OF MULTI-BEAM DATA

Prepared by:

Hanna Nengerman

Jan De Nul GROUP



INTRODUCTION

My first project during my internship was a project in Taiwan, Kaohsiung. The harbour of Kaohsiung had to be dredged and the sand needed to be dumbed at a dumpsite. The client was going to extend the harbour. Jan de Nul had the job to dredge the harbour to a certain depth. During this project there had to be done a survey almost every day. The dredging ship, the Charles Darwin, dredged all day and all night, so they needed an update of the seafloor quite often. After doing a survey the data needed to be filtered. Filtering a dredging area can be tricky because sometimes the survey had to be done while the ship was dredging.

For the Standard of Competence reports we had to choose three different subjects. This SOC report is about approximation and estimation. In the document where all the different SOC subjects are described, this subject is described as follows: Describe methods for estimating and approximating static and dynamic survey measurements. Apply and analyse filtering and cleaning functions using appropriate software.
I chose this subjects because I find the processing of the survey data very interesting. During my internship I have to do the processing of the survey data. I think I will learn a lot about this subject and will have enough information and results to put in this report.

In this report I will first tell something about filtering survey data in general, then about the program we used to filter the survey data, AutoClean. I will talk about how to set up a project and the different filters that are possible to use. Lastly, I will tell about the filters that are used to filter the survey data at the project in Kaohsiung and what these filters did to the data.

TABLE OF CONTENTS

1 FILTERING SURVEY DATA

Filtering the survey data is very important, because you want to make sure the data is accurate and no false depth are shown. The survey data has to be cleaned because there can be points in the data that don't represent the actual seabed. Those points are called 'spikes'. Spikes can be formed because of fish or bubbles of air in the water. They can also be formed because of cloudy water. Cloudy water spikes are common at a dredging project, because the dredging ship creates cloudy water.

So to get those spikes out of the survey data the data have to be filtered. This can be done by hand or automatic. Some recording programs can also filter the data during a survey, Qinsy for example. In Qinsy you can set a minimum and maximum depth and when the data points get under or above those settings those points will be filtered. When you load this data in any filtering program, those filtered points will not be shown. So you need to pay attention for these filters during a survey.

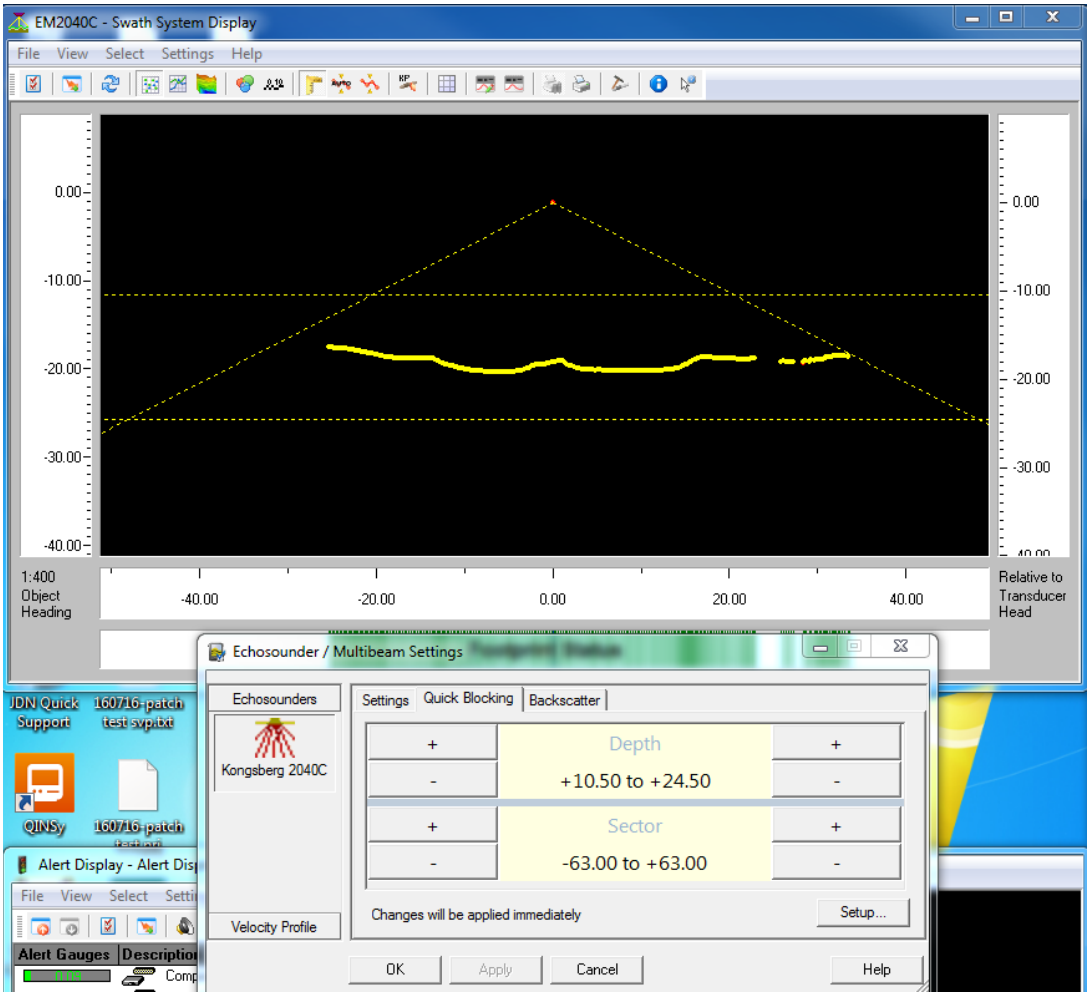


Image 1 Qinsy Multibeam footprint and filters

In the top half of the picture you can see the swath of the multibeam and in the bottom half of the picture you can see the settings for the minimum and maximum depth. All points under or above the given depth will be immediately filtered. You can also set the sector of the multibeam. The data at the end of the sector will be less accurate so you can choose to remove 1 degree or more at both sides of the multibeam range.

After the survey is done you can also filter the data by hand. In most data filtering programs you can select an area that you surveyed and filter the data. How this will look in AutoClean, the program used at this project, will be shown in a following chapter.

If the area you surveyed is big it will take a very long time to filter the data by hand, which is why most programs also have automatic filters. You can turn on and off what filters you want or even ad a new filter. After that you can filter the whole survey in one time. Remember to always check the data after doing this because the automatic filters will not always delete all the spikes in the data or remove data that should not be removed. To check the data before filtering the whole data you can (at least in AutoClean) choose to ‘show preview’. In that way only the area you selected will be filtered and you can check what the filters will do to the data.

2 AUTOCLEAN

At the project in Kaohsiung we used the program 'AutoClean' to filter the survey data. Jan de Nul always uses this program. Before they used AutoClean they used Qloud, which is the processing program from Qinsy. Now Qinsy has made a new processing program, Qimera. This program is still under progress because it is quite new. That is why Jan de Nul chooses to use AutoClean instead.

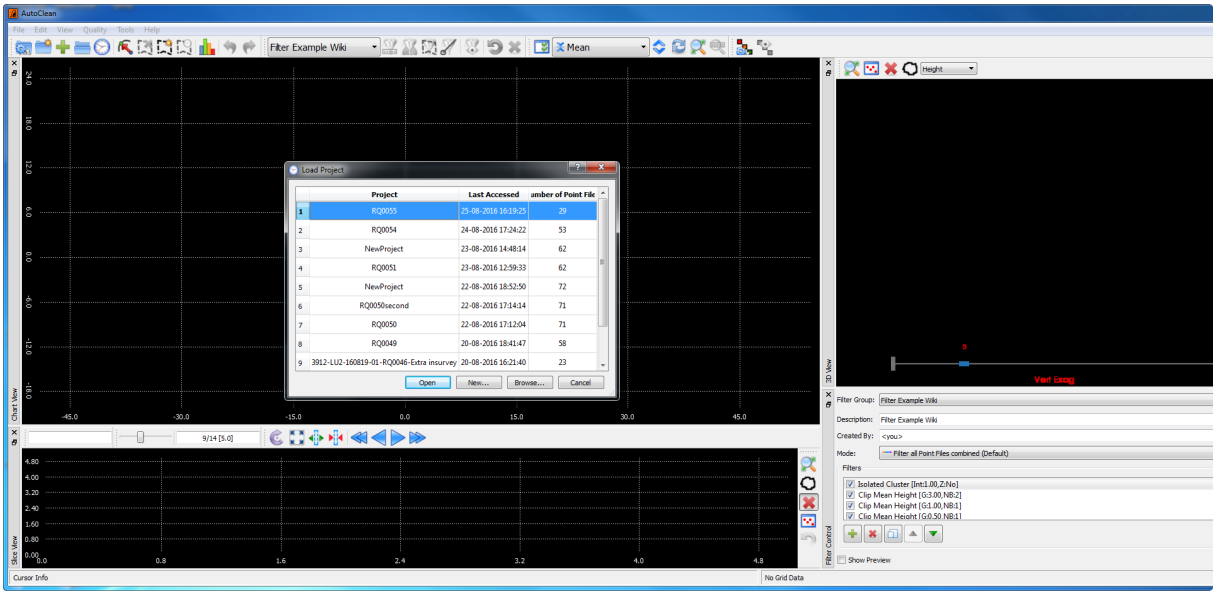
AutoClean is a BeamWorX program to quickly process point data sets. It can automatically load and clean data. Various reporting tools assist the user to verify the data quality.
AutoClean can only be used with a dongle, so it is a program that has to be paid for.

Image 2 AutoClean logo

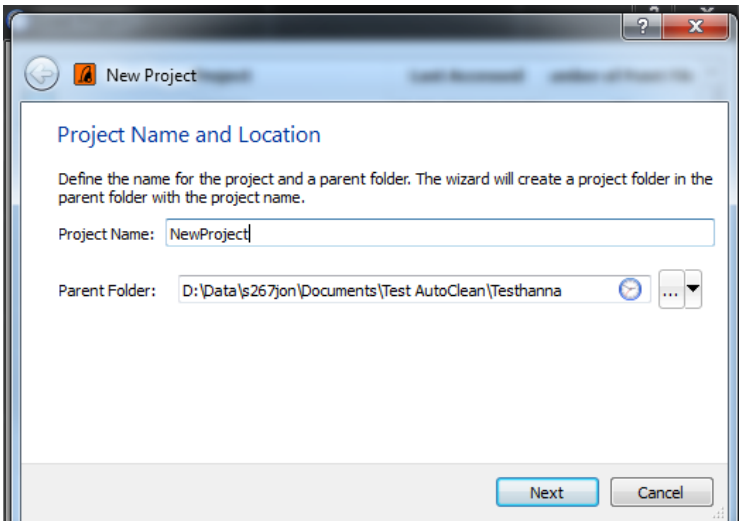
2.1 HOW DOES AUTOCLEAN WORK

Below will be shown and explained how to create a project in AutoClean and what the settings were used at this project.

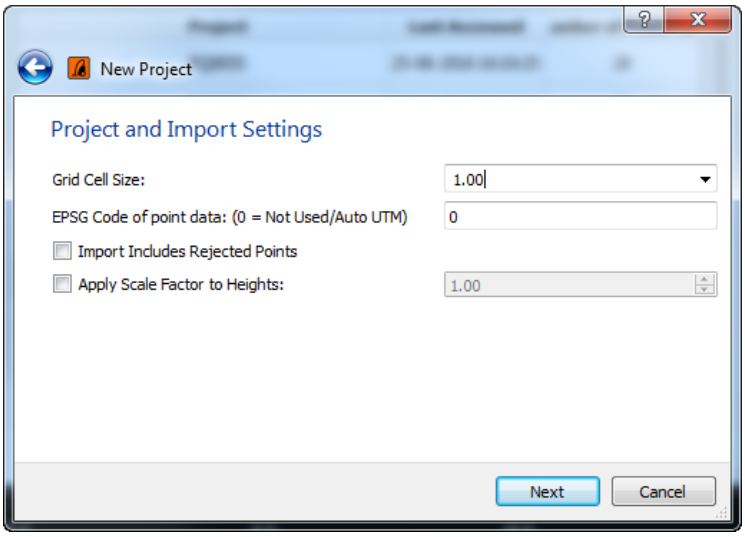
Step 1: Open AutoClean after inserting the dongle and choose new project.



Step 2: Name the project and choose a place to save the project.



Step 3: Choose the Grid Cell Size and if you want to use a EPSG Code of point data you can also choose that code in this display. The EPSG code is a structured dataset of Coordinate Reference Systems and Coordinate Transformations. At this project we didn't use an EPSG Code so it automatically switches to UTM. Grid Cell Size has to be the same size as used during the survey. At this project we used a Grid Cell Size of 0.5.



Step 4: Add a folder or files. This has to be the DTM data of the survey otherwise the program will not recognize the data.

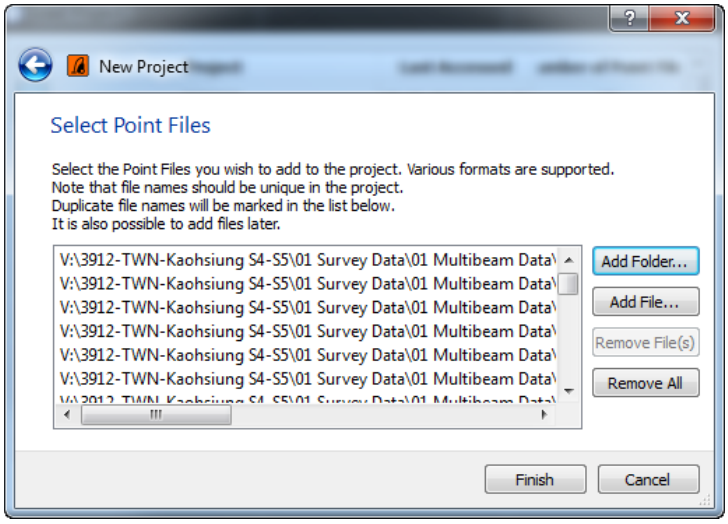


Image 3-6 Explanation setting up a project in AutoClean

After clicking op Finish the data will be shown in AutoClean and you can start filtering the data.

2.2 FILTERS IN AUTOCLEAN

In the list below are the filters shown that are currently available in AutoClean. There is also a small explanation given by the filters.

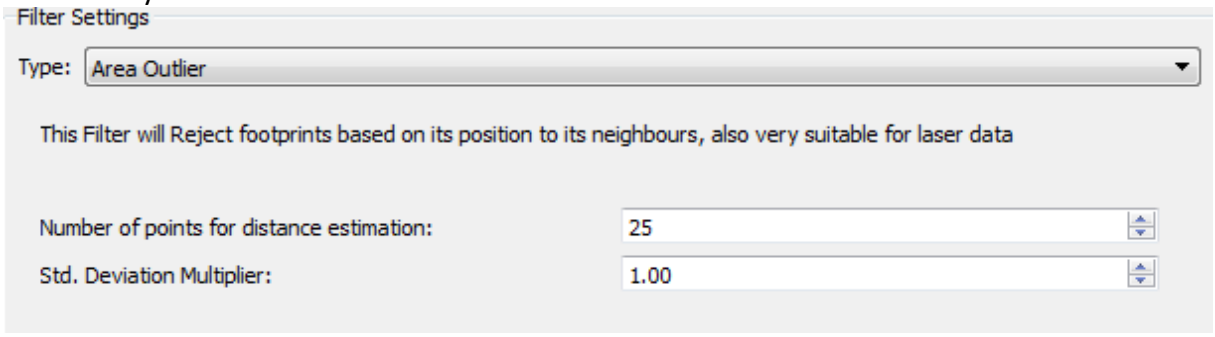
Filters	Description
Area Outlier	Reject based on mean distance to its neighbours
Basic Ping Blocking	Rejects based on relative position w.r.t. the transducer position
Clip Abs. Height	Reject on absolute point height
Clip Grid Reference	Reject points based on height difference w.r.t. the grid reference layer
Clip Mean Height	Rejects footprint in cell(s) based on mean height and gate
Edit Classification Filter	Will change the point classification and/or status
Isolated Cluster	Reject points that are located in an isolated cluster (group)
Lonely Cells	Reject points that lie in isolated grid cells
Low Hit Count	Rejects all footprints in a cell when cell does not contain enough points
Overlap Fixer	Fixes height errors on overlaps cause by refraction errors
Reducer – Voxels	Voxel (3D box) based reducer
Refraction Correction	Allows to correct for refraction errors due to SVP changes during acquisition
Reset Modification	Reset any kind of modification
Slope Filter	Reject on mean slope to neighbours
Surface Spline Filter	Reject based on fitting a thing plated spline through patches of points
Vertical Plane	Rejects vertical planes from data
95% Confidence Level	Statistical outlier rejection based on cell mean

Table 1 Filters with description

All filters above will be explained in detail on the next page. All filters described on the next page are based on the actual Grid Size of the Chart View, smaller of larger grid size will give different result.

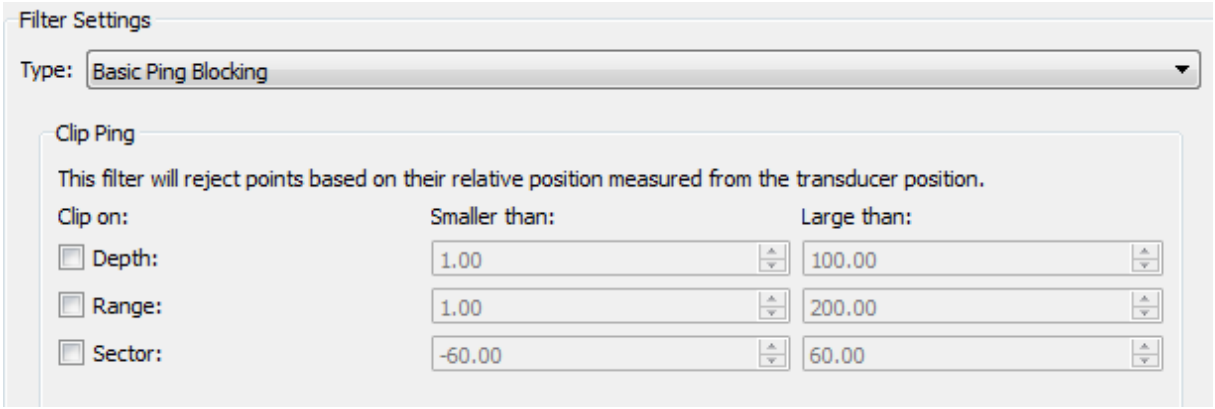
Area Outlier

This filter will reject points based on its mean distance to its neighbours. Points are rejected when the Standard Deviation of the distances is larger then the user defined threshold. This filter is very effective for laser data.



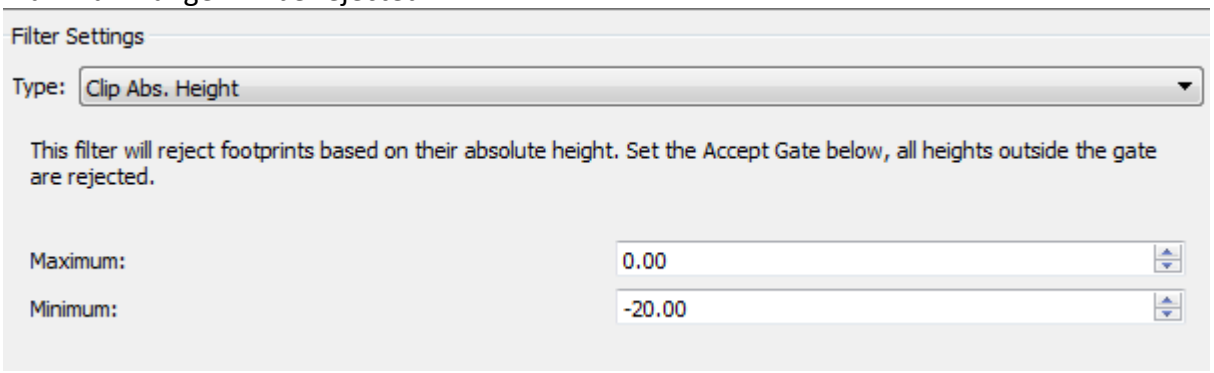
Basic Ping Blocker

This filter will reject points based on their relative position measured from the transducer. One can select the preferred clip properties simultaneously. Most formats, like FAU or XYZ, do not contain a transducer position. AutoClean estimates the transducer position and height from available point properties during import, therefor do not set the filter gates too tight.



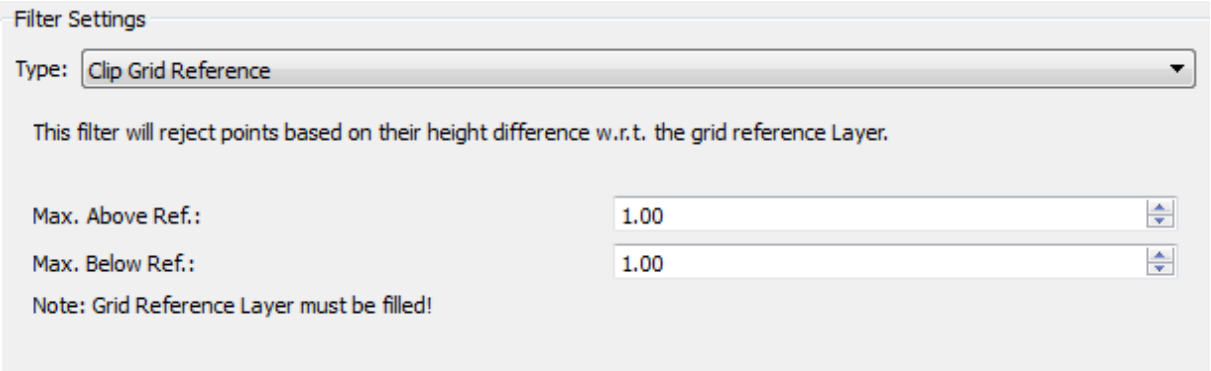
Clip Absolute Height

This filter will reject points based on their absolute height. Points outside the minimum and maximum range will be rejected.



Clip Grid Reference

This filter will reject points based on their height difference w.r.t the grid reference layer.



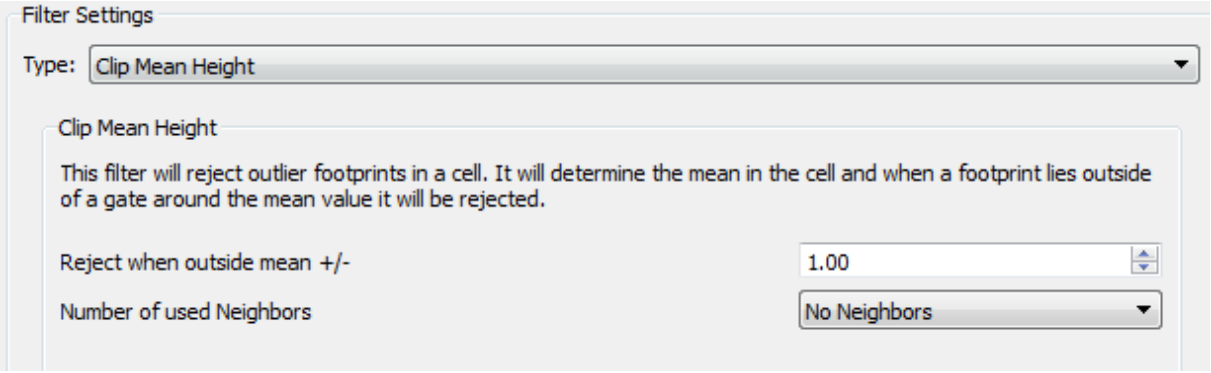
Clip Mean Height

This filter will reject points in a cell that has a bigger height offset from the mean that is set by the user. The user defined *Number of Neighbours* is used to calculate the mean value.

Setting "No neighbours" will force the algorithm to create a virtual cell around each point position. This means that the point to be evaluated is always in the centre of the cell. During evaluation the examined point does not contribute to the used mean value.

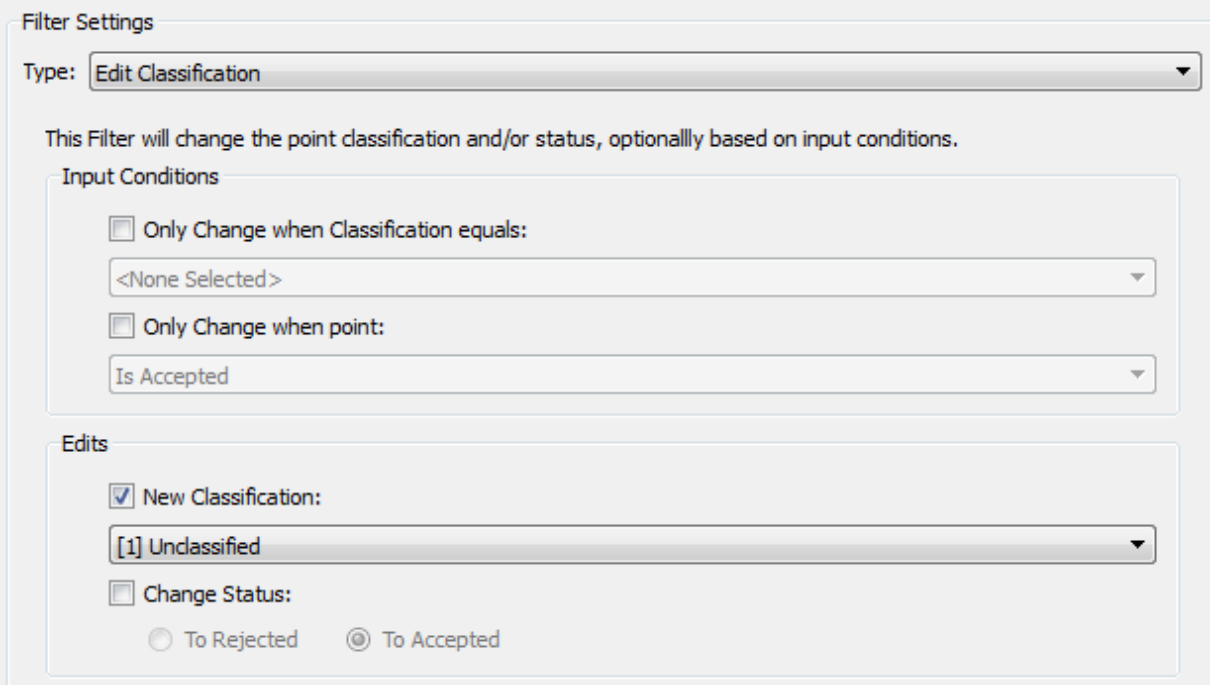
"1 Neighbour and more" will force the algorithm to adapt to the neighbouring mean of the cells. The *Reject when outside mean +/-* gate is applied to the minimum and maximum found in the virtual cell and the neighbouring ring.

Do not use Clip Mean Height with 2 or more neighbours with rejects outside mean < 1.0m. This will remove valid data.



Edit Classification Filter

This filter will change the point classification and/or status, optionally based on input conditions.

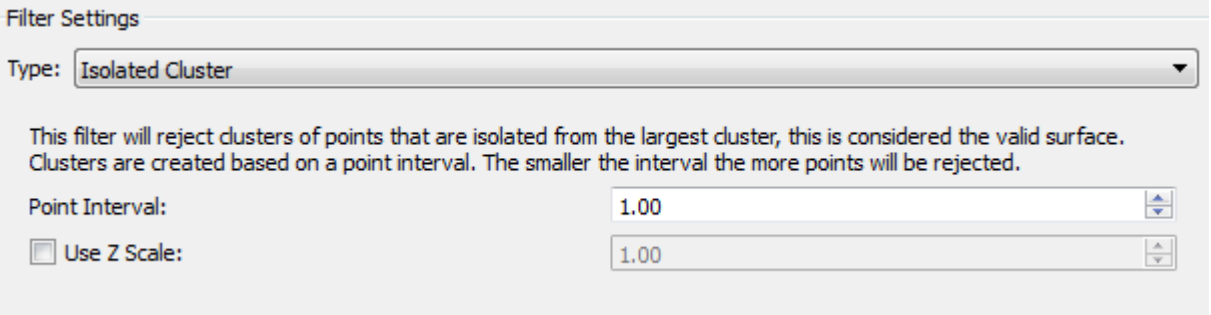


Isolated Cluster

This filter rejects points that are located in an isolated cluster group. All points that lie within the 3D distance (**Point Interval**) of each other are added to a cluster. This way separate point clusters are created.

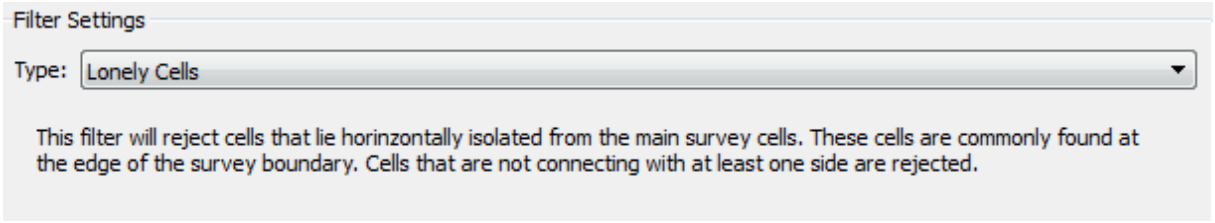
Clusters that are not on the partition boundaries of the main cluster will be removed (Lonely Data).

The **Use Z scale** is to modify virtually the vertical distances between the points and so adjust the filter vertical sensitivity. The smaller the Point Interval the more points will be deleted.



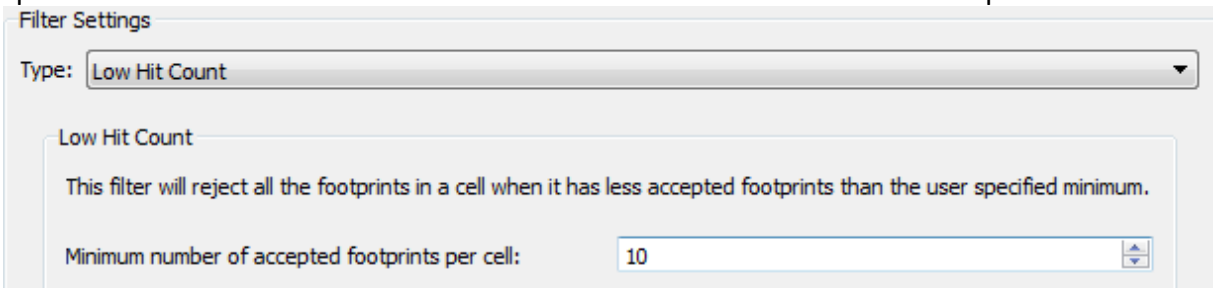
Lonely Cells

This filter will reject points that lie in a sounding grid cell that is isolated from the 'main survey cells'. The filter is based on grid cells, it will only look in the horizontal direction, this in contrast to the filter 'Isolated Cluster' that will reject in 3D. Cells that are not connected with at least one cell side to the main survey area will be removed.



Low Hit Count

This filter will reject all the points in a cell when it has less accepted points than the user specified minimum. Cells with less than 10 hits will be removed in the example below.



Overlap Fixer

This filter corrects for refraction errors on file overlaps. It will either modify the point heights or reject the point with higher beam angle to remove the refraction error.

For each cell the filter calculates the *"mean height value"* and *"average beam angle"* per line in the specific cell.

Modify Heights

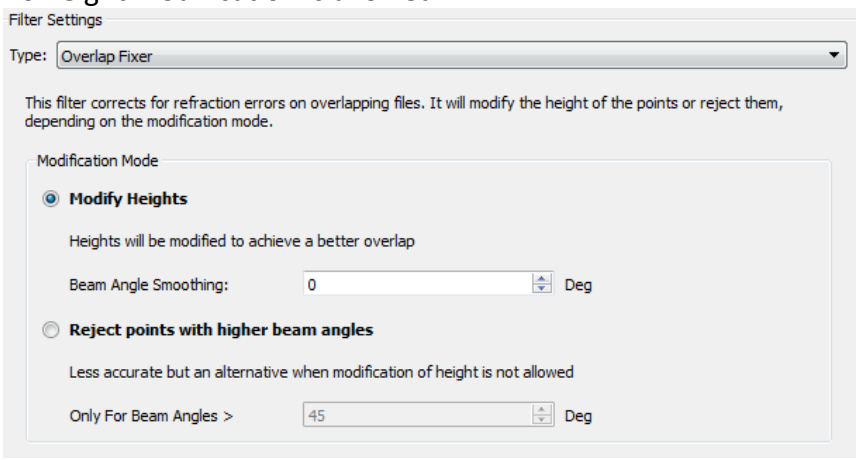
The points from the lines with a higher average beam angle will be height shifted with the offset in the cells mean per line compared to the cell with lower average beam angle.

Beam Angle Smoothing: This is used to make the overlaps smoother. Typical value for this is 5 to 10 degrees.

Reject points with higher beam angles

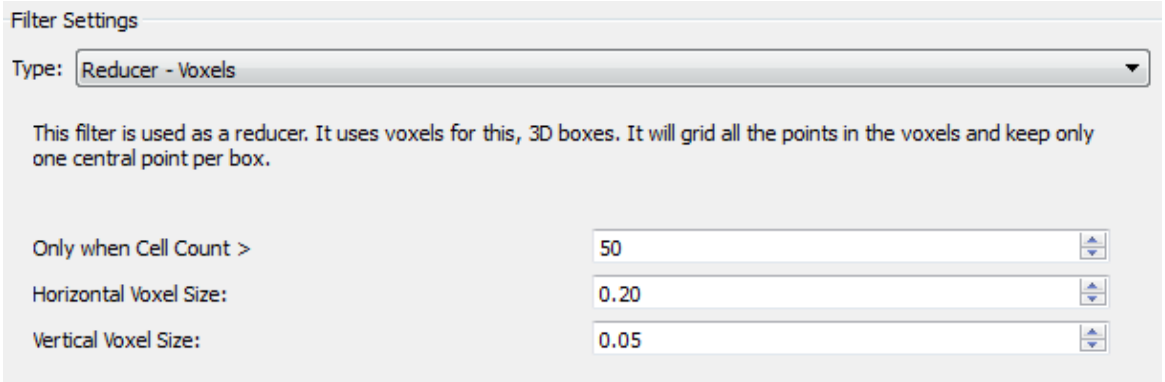
No height modifications are carried out but instead the points with a mean higher beam angle will be rejected. This should be used for Beam Angles higher than 50 degrees.

Modify Heights mode will give the best results. Use *Reject points with higher beam angles* when no height modification is allowed.



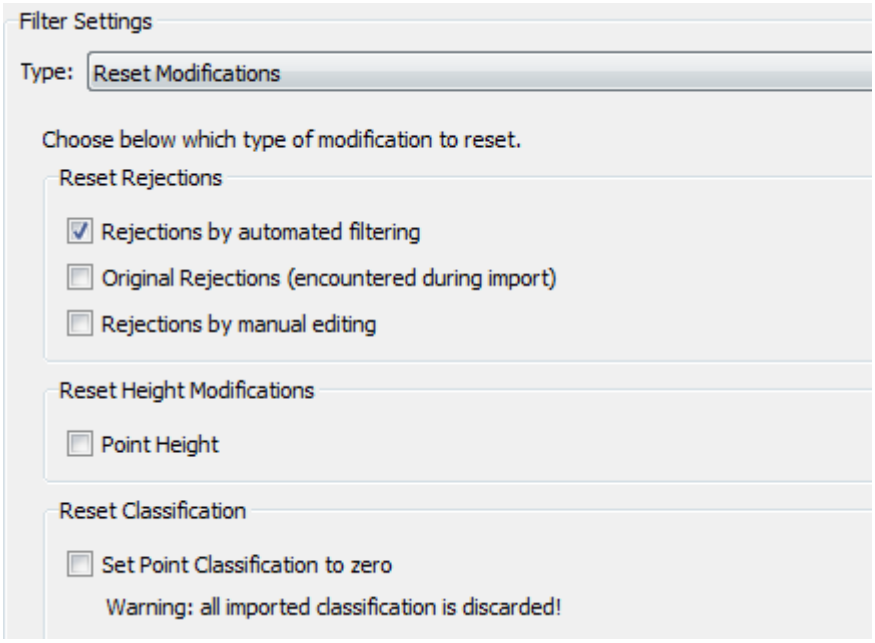
Reducer – Voxels

The Voxel filter is a dataset reducer, it creates 3D cells with the user defined dimensions. The points closest to the cell centre remain, the other points will be rejected. The used voxels are aligned with the grid if possible. The voxel filter is quite useful to remove duplicate points. Set the Horizontal and Vertical Voxel Size to 0.01.



Reset Modifications

This filter will reset a modification.



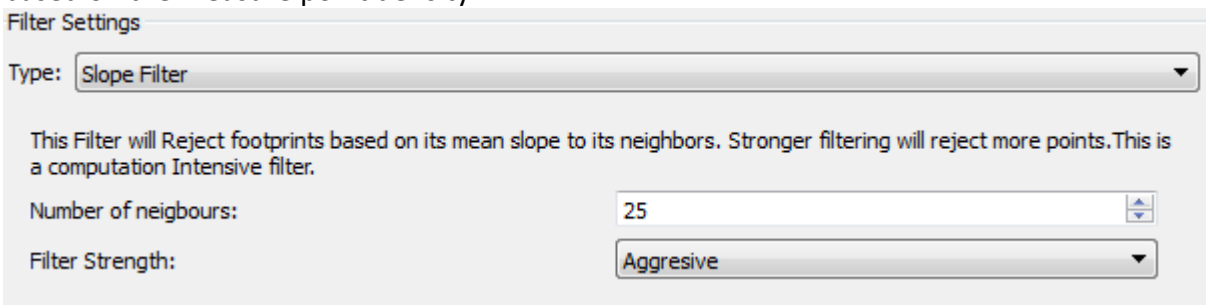
Reset Rejections

This filter is used to reset one or more rejection flags of the points. It can be used directly form the Chart View as well with the icon, which is shown below.

This filter can only be used as the first filter of a filter group. This can be handy to reset any modification prior to applying the other filters in the filter group.

Slope Filter

This filter will reject points based on its mean slope to its neighbours. The filter strength goes from weak to aggressive, aggressive will reject more points. Set the number of neighbours based on the measure point density.



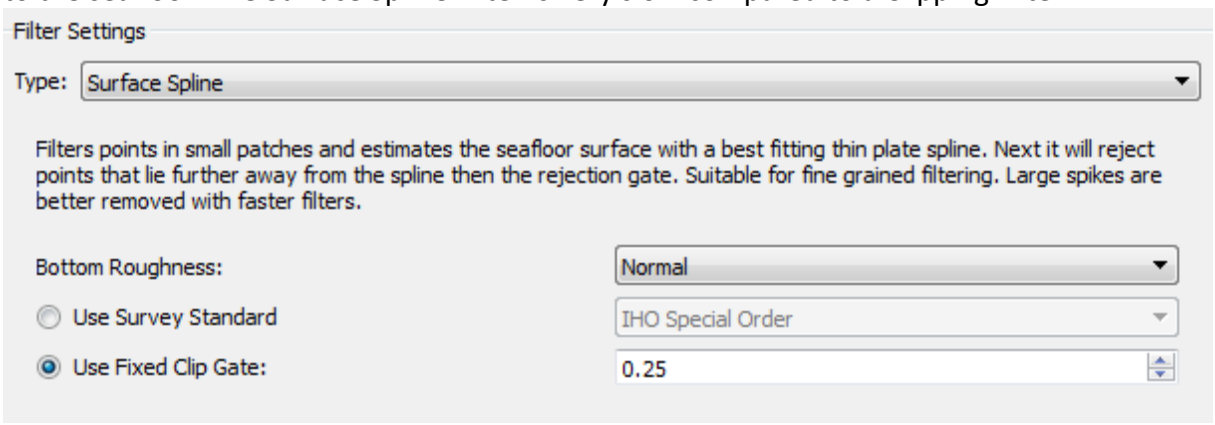
Surface Spline Filter

This filter rejects points based on fitting of a thin plated spline trough patches of points. When the point distance to the thin plate spline is larger than the *Reject Gate*, then the point is removed.

Settings:

- Bottom Roughness: From Very Flat -> Very Rough: In most cases, normal will do just fine.
- Survey Standard: The depth of rejection is determined by taking an overall transducer height and subtracting the point height of it. With a and b as parameters of the Survey Standard the clipping gate is calculated.
- Fix Clip Gate: This is a user defined fixed value to determine the rejection.

The Surface Spline Filter should always be preceded by a filter that takes out the large spikes: Isolated Cluster or Clip Mean Height. This filter is typically used for removing small noise close to the seafloor. The Surface Spline Filter is very slow compared to a Clipping Filter.



Vertical Plane

This filter is designed to remove quay walls. It rejects a vertical plane from the data in the Inspection Area.

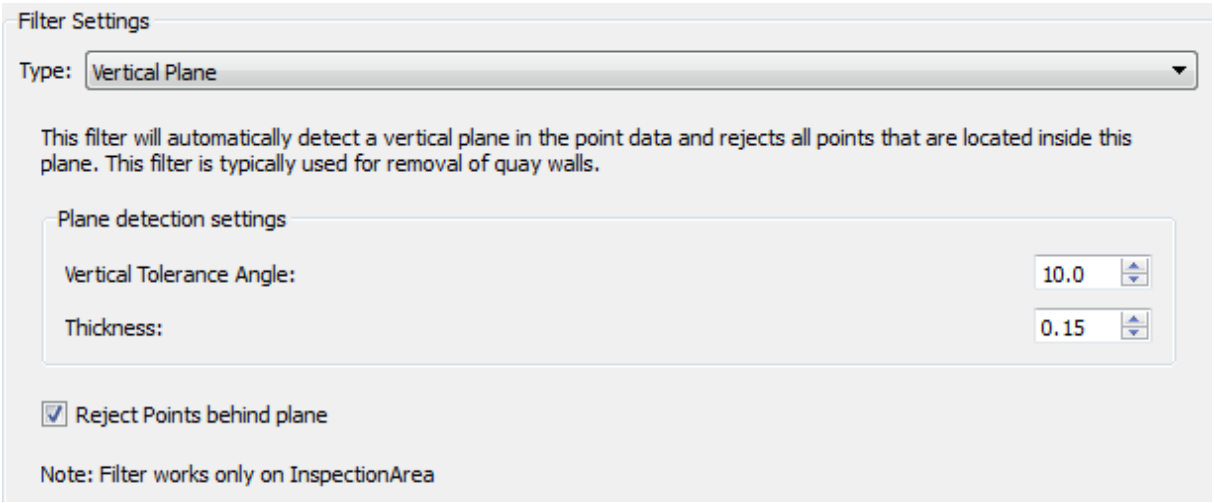
Vertical Tolerance Angle: This is the maximum tolerance of the vertical wall that must be removed from the dataset. Do not set it too tight.

Thickness: This is used to define the thickness of the plane.

Reject Points behind plane will remove all points behind the plane. Behind in this case is seen from the transducer.

This filter can only be applied on the current Inspection Area because it will remove only a single plane.

This filter only works properly on quay walls of 5-10m, not on a small wall of 1-2m.



Confidence level

This filter will reject the worst outlier point in a cell in comparison to the cell mean value. It will do this iteratively until the confidence level of the cell has fallen below the maximum user specified value or when the minimum valid point count is reached.

The Overlap Mode:

- *Normal statistics* should be used as standard
- *Relative to mean height per file*, the filter will first create a temporary cell that contains all points but shifted to the mean height compared per line.

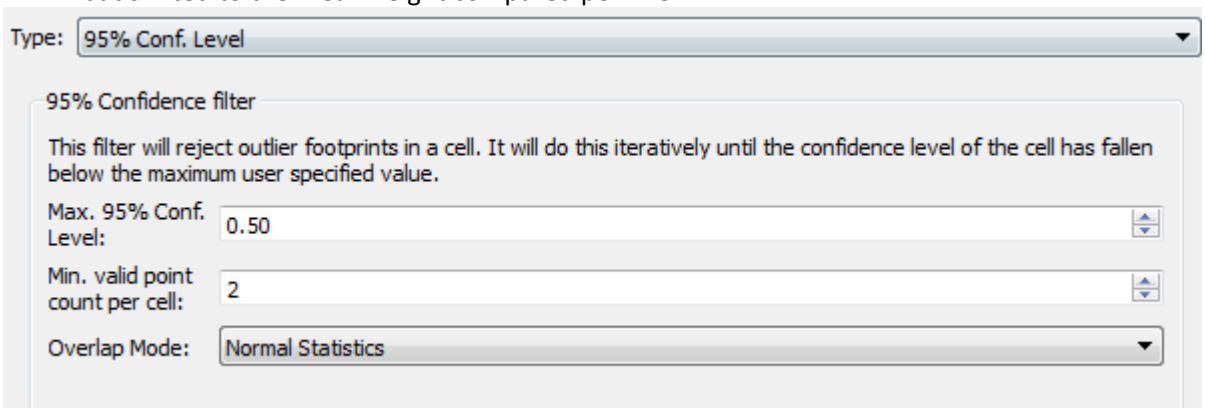


Image 7-18 Filters with detailed explanation

3 FILTERS USED AT SITE

At this project we used the following filters:
-Isolated cluster
-Clip mean height
-Lonely cells
-Surface spline [Normal, IHO Special Order]

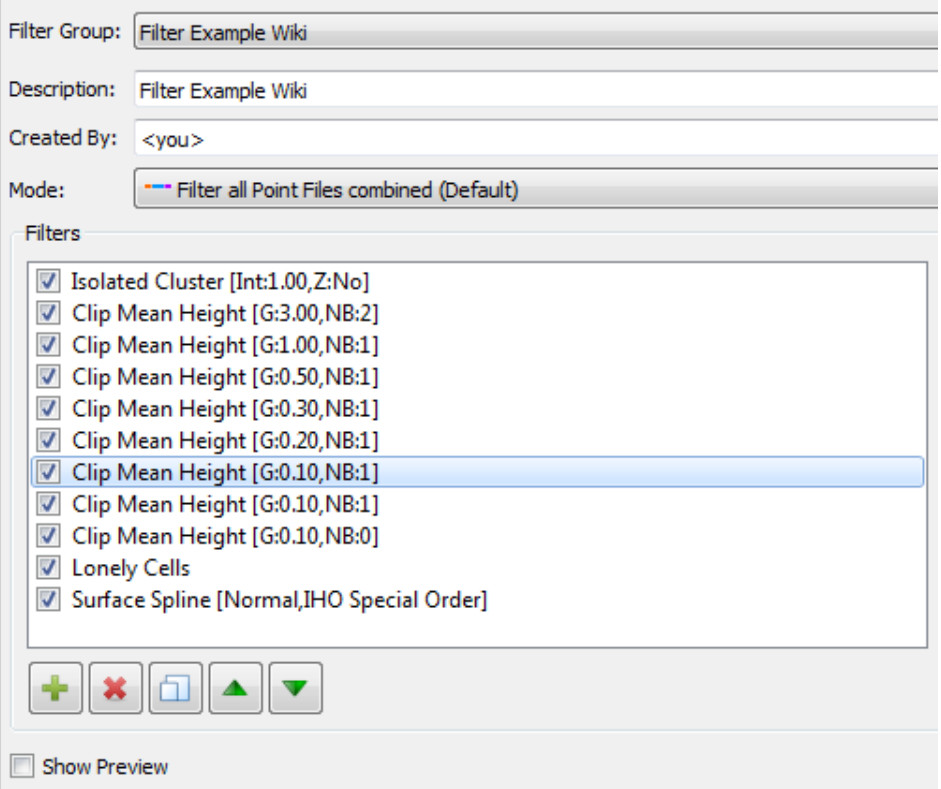


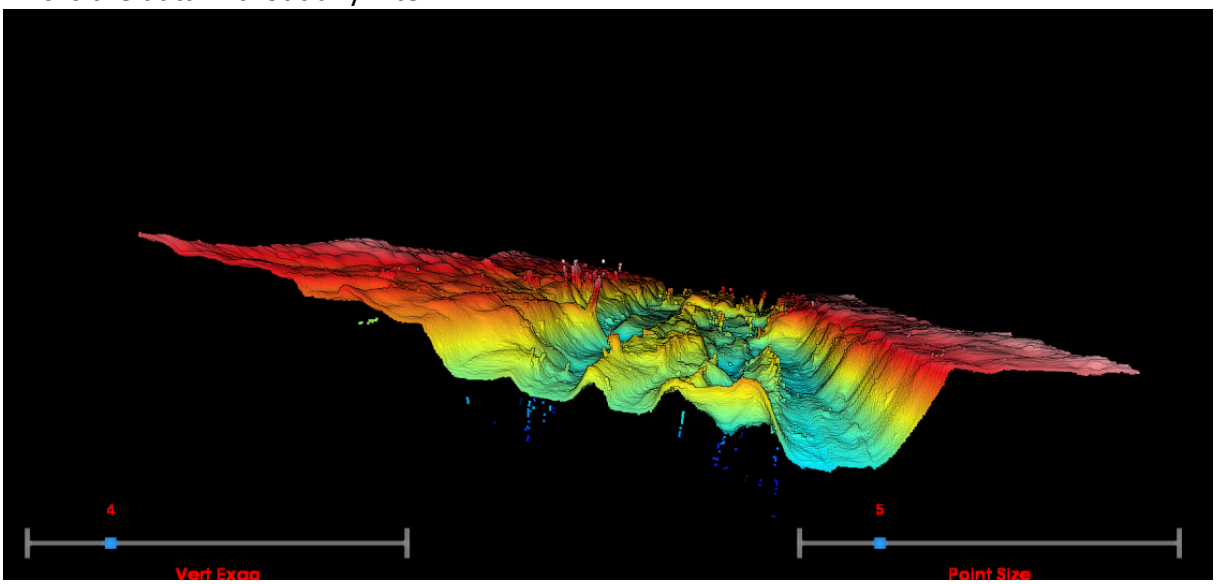
Image 19 Filters used at project

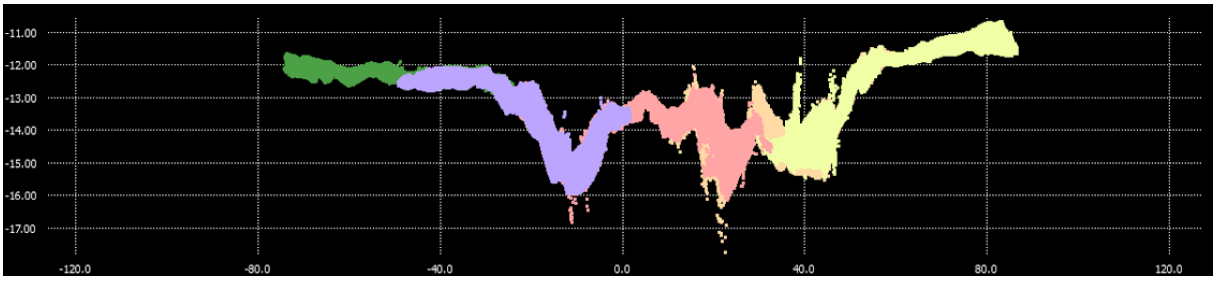
In the previous chapter is already explained what these filters do and out of experience these filters worked the best with the survey data at the project. Sometimes we also used overlap fixer when there was a lot off overlay problems between the lines.
You can see there are many Clip Mean Height filters, these are all set to a different distance to the mean. Also some of the filters use a different number of neighbours. What this means can be read in the previous chapter.

4 RESULTS

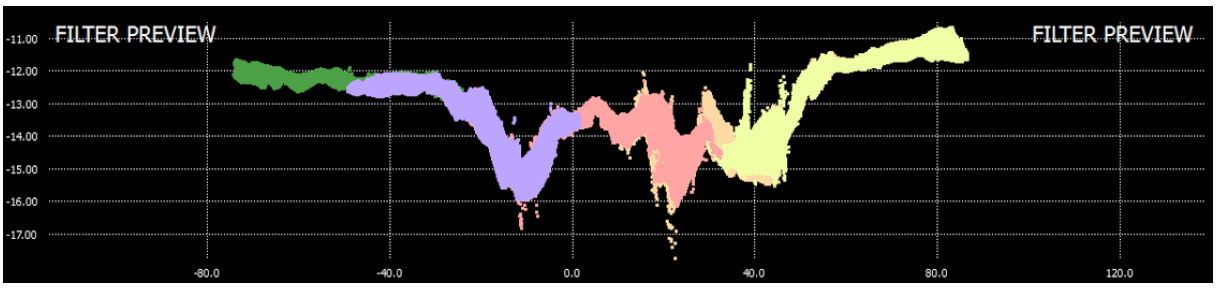
In this chapter I will explain what all the filters used at the project in Kaohsiung did to the survey data. I used an area where I thought the effect of the filters will be seen best. The data used below is the data from August 24.

This is the data without any filter.

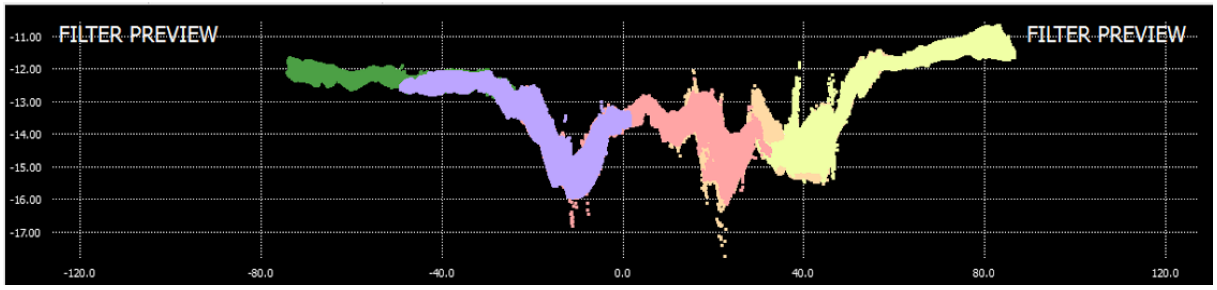




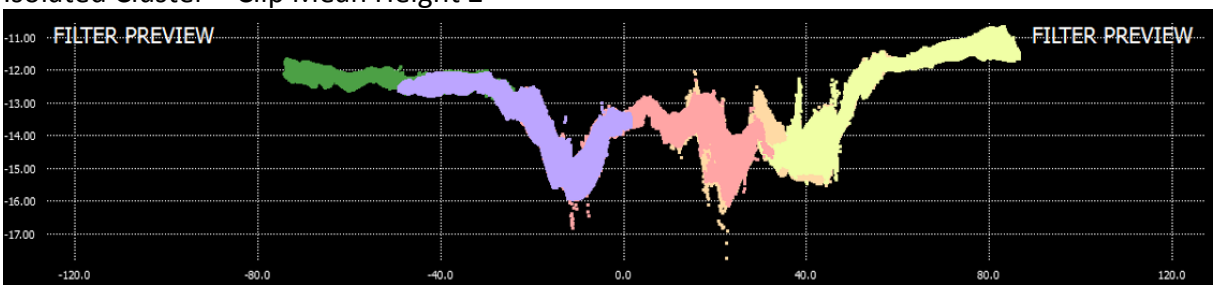
Isolated Cluster



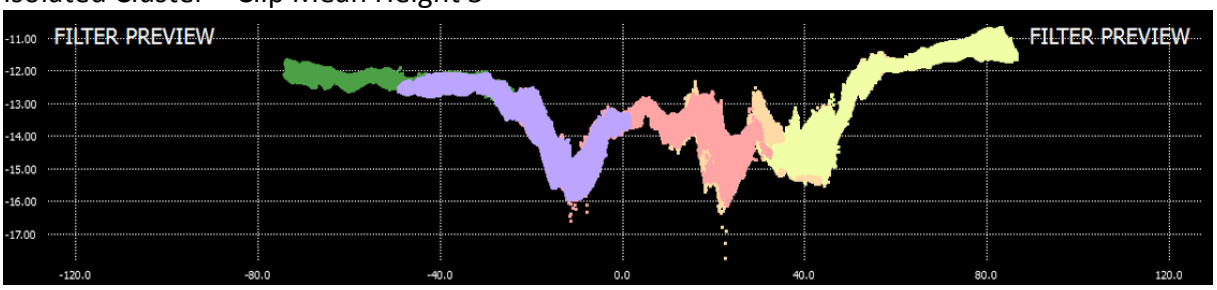
Isolated Cluster + Clip Mean Height 1



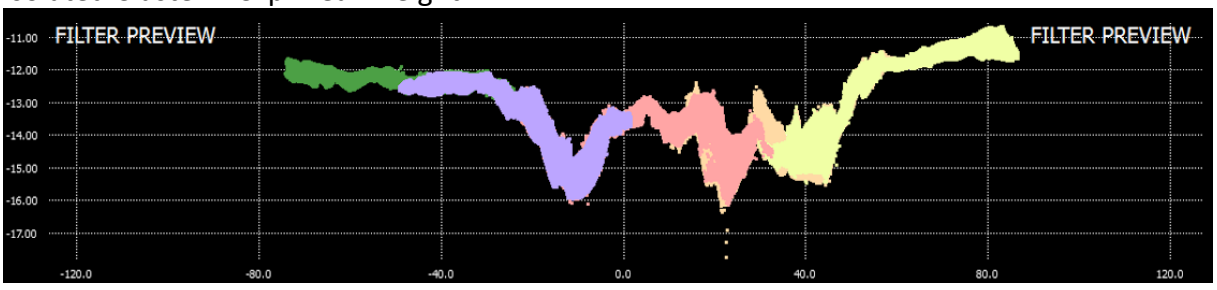
Isolated Cluster + Clip Mean Height 2



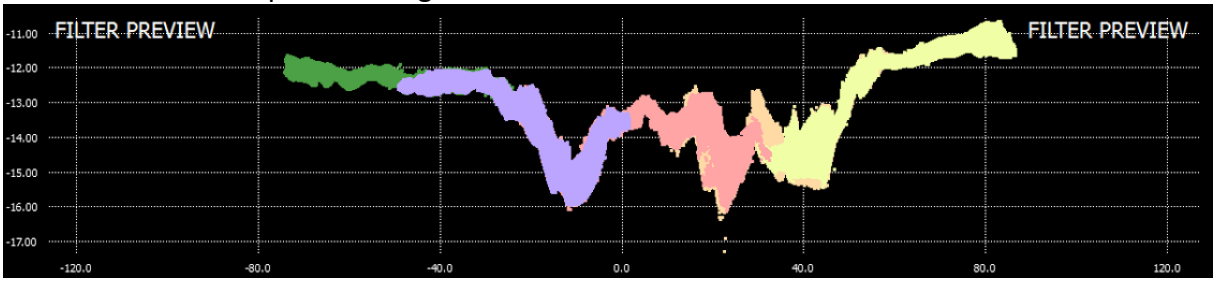
Isolated Cluster + Clip Mean Height 3



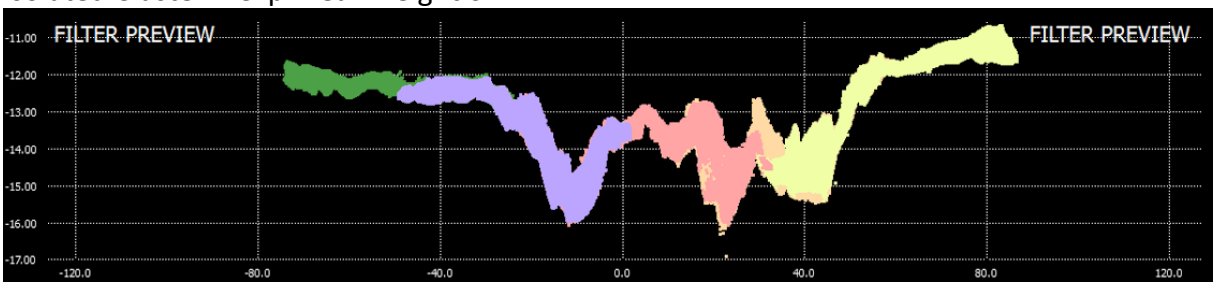
Isolated Cluster + Clip Mean Height 4



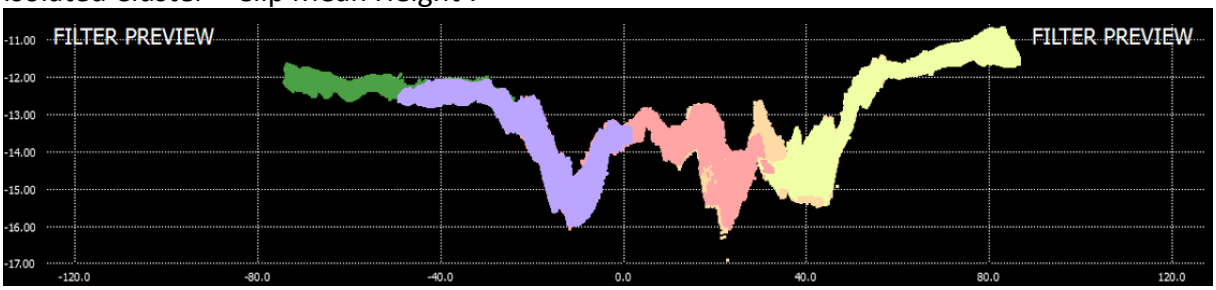
Isolated Cluster + Clip Mean Height 5



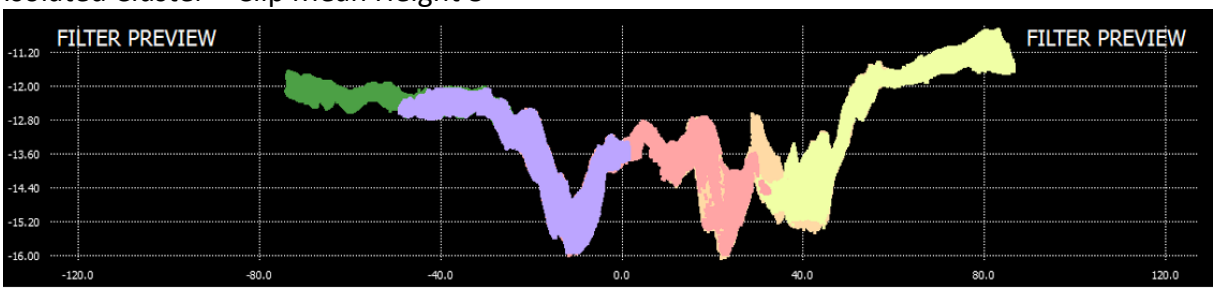
Isolated Cluster + Clip Mean Height 6



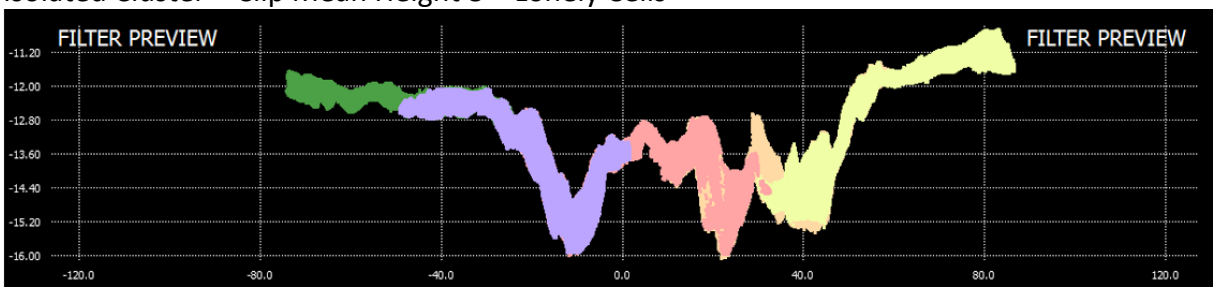
Isolated Cluster + Clip Mean Height 7



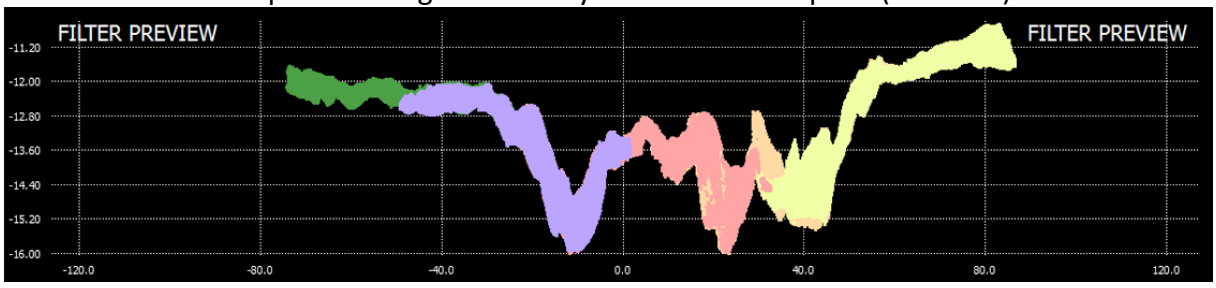
Isolated Cluster + Clip Mean Height 8

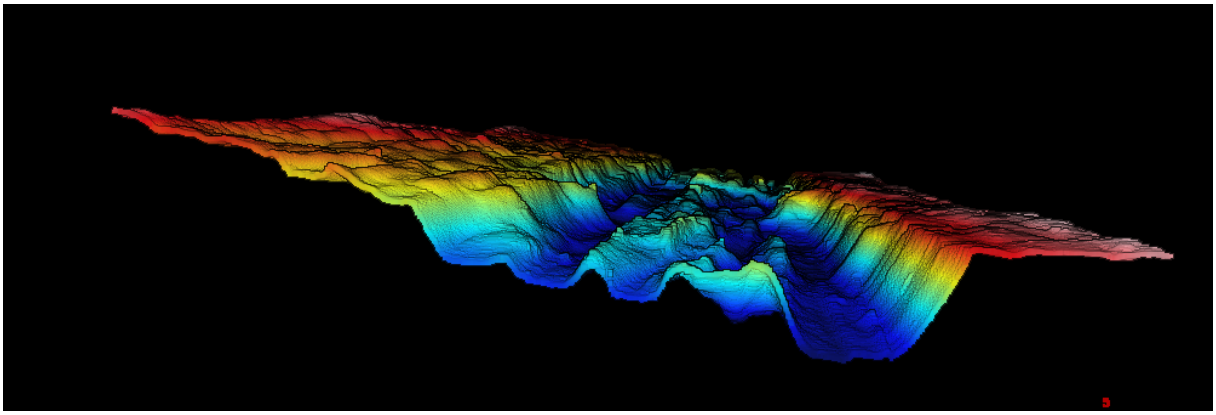


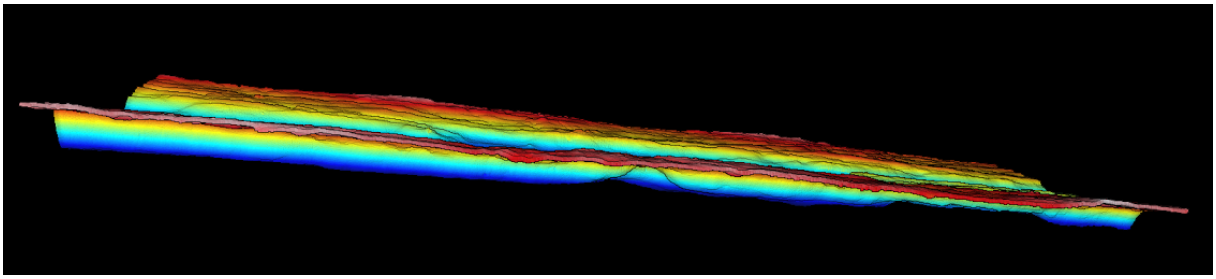
Isolated Cluster + Clip Mean Height 8 + Lonely Cells



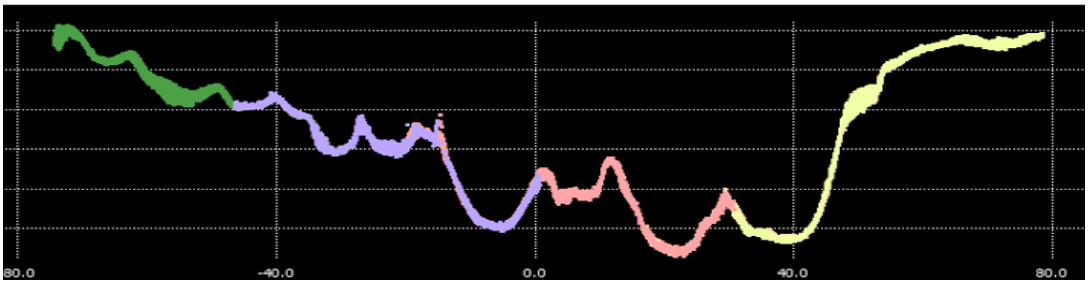
Isolated Cluster + Clip Mean Height 8 +Lonely Cells + Surface Spline (all filters)

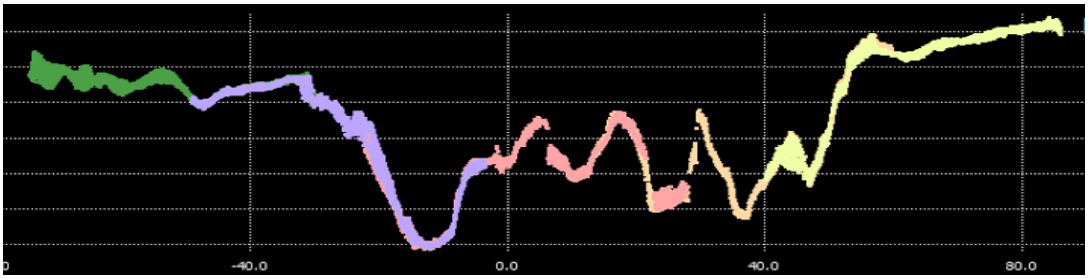






In the pictures below you can see a smaller area of the data with all the filters. You can see that there are still some spikes left, which the automatic filters didn't filter out. There is also a part in the second picture where the filters deleted good data. Overall these filters do a very good job at filtering the data. On the day of this survey the Charles Darwin wasn't dredging close to the survey vessel so there was almost no cloudy water and the filters could determine the good data easier.

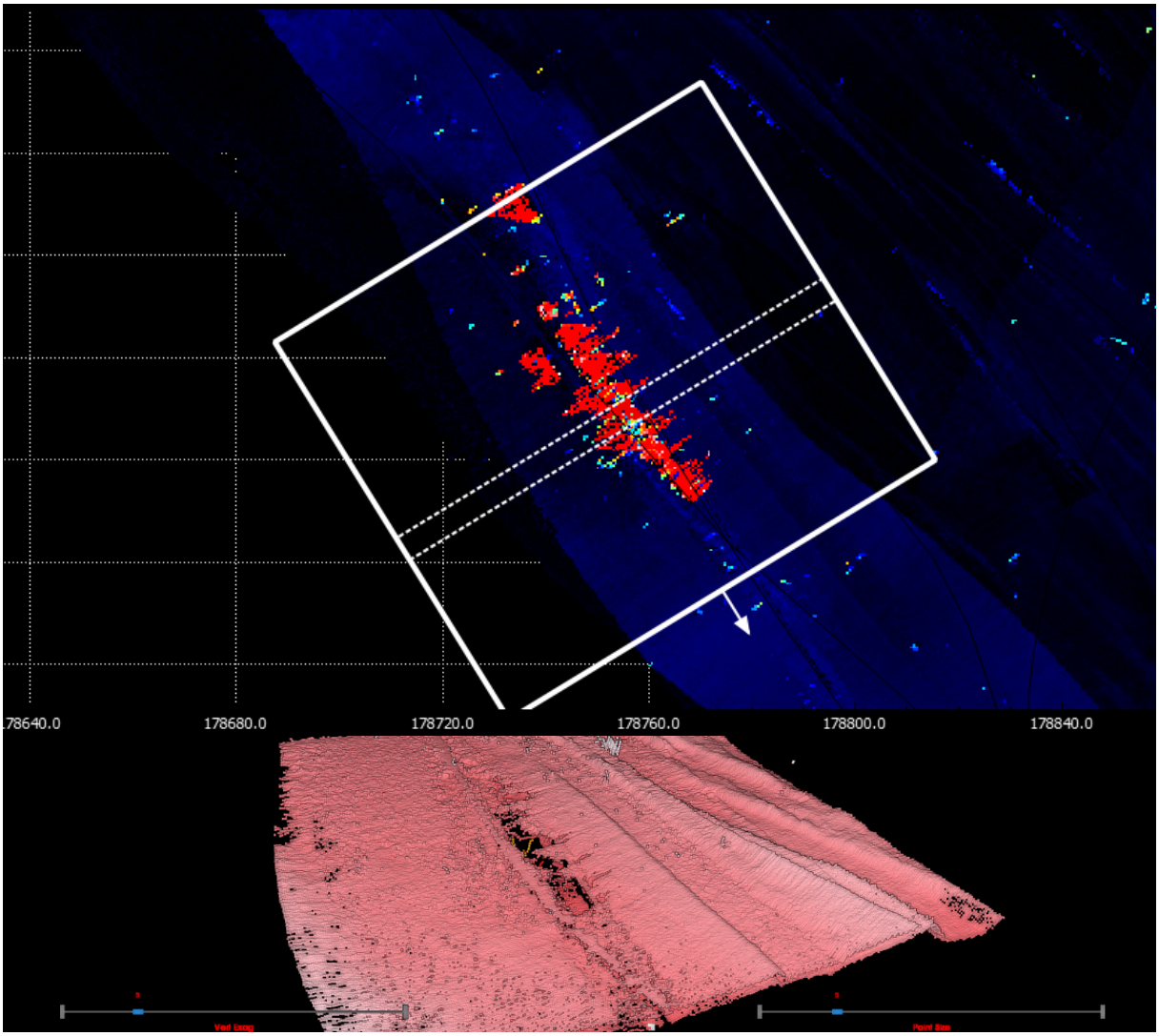


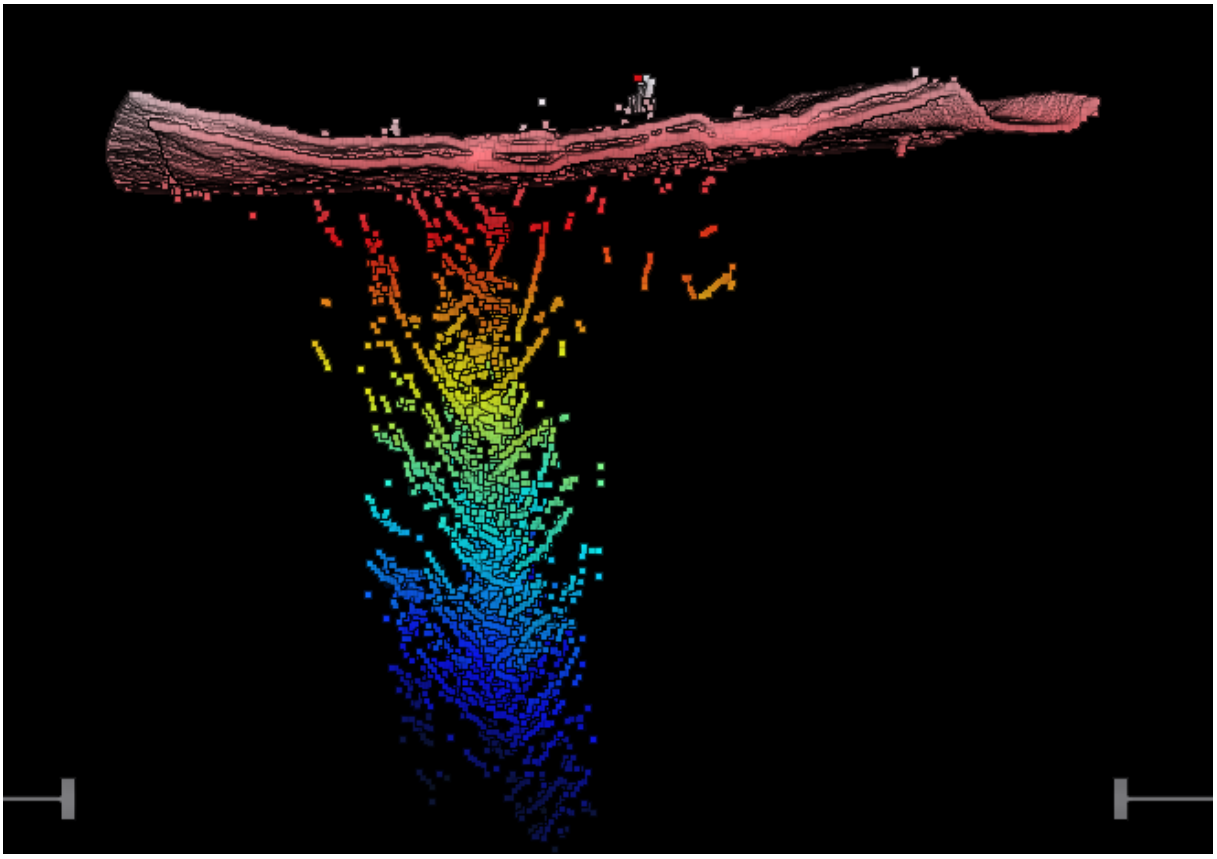


In the next examples is shown what will happen if you use all the filters on specific data without checking it.

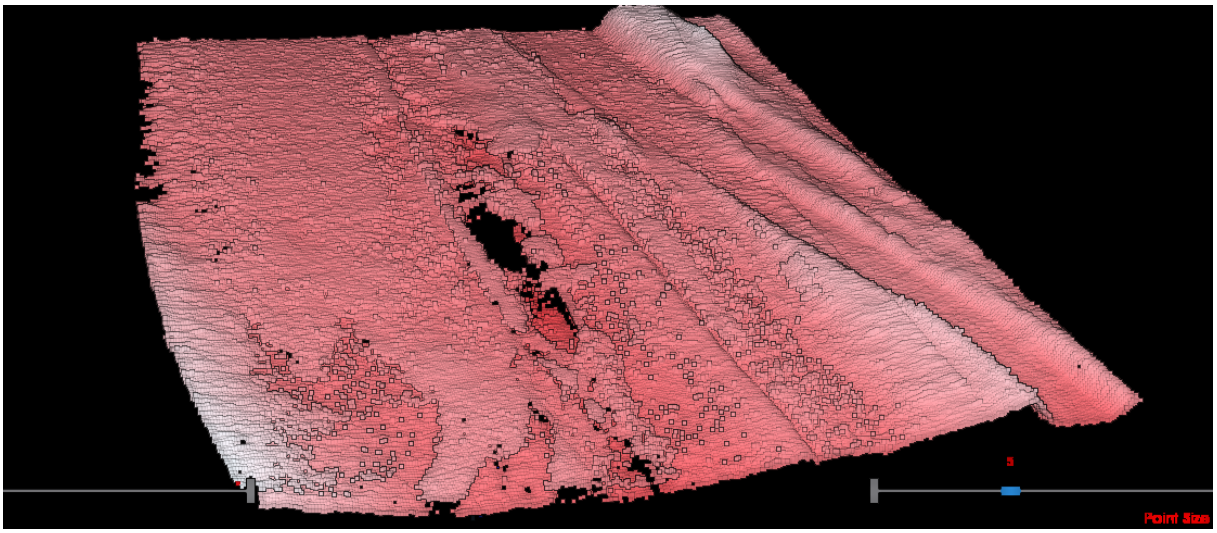
The first example is an area where the 95% confidence interval isn't made. After all the filters are applied also good data is filtered out and not all the bad data is filtered out.

Before filters



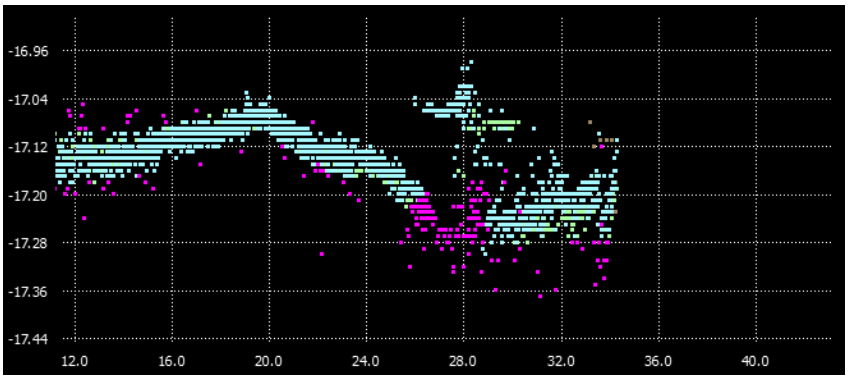


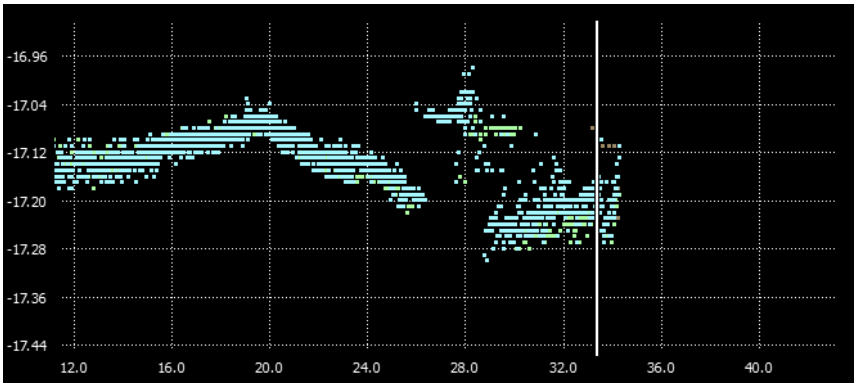
After filters



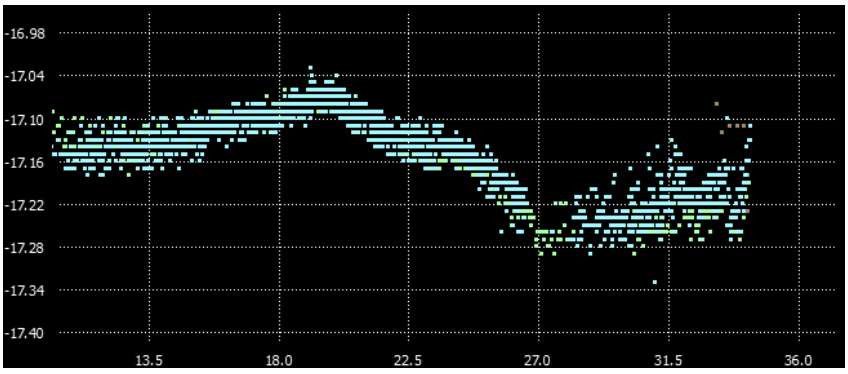
In the second example there is a bit of noise in the data and the program filters out the good data and keeps the bad data completely.

This is what the data looks like after it is filtered, as you can see there is a 'pancake', which can be formed by trouble water. The real seafloor is filtered out. The purple points are points that are deleted.



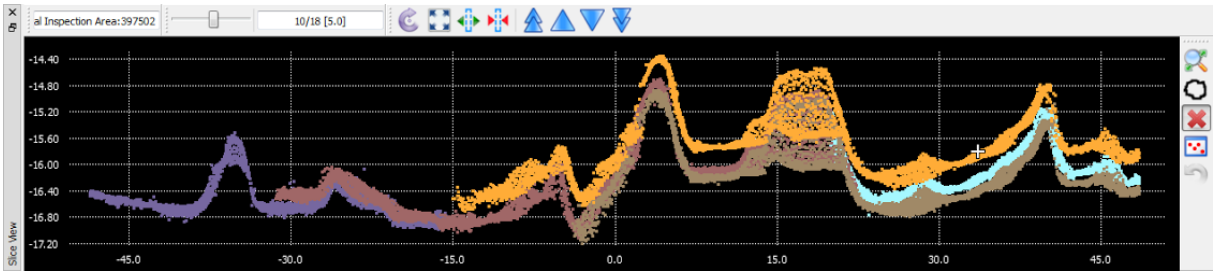


You can fix this by filtering this part of the data manually and then it should look something like this.

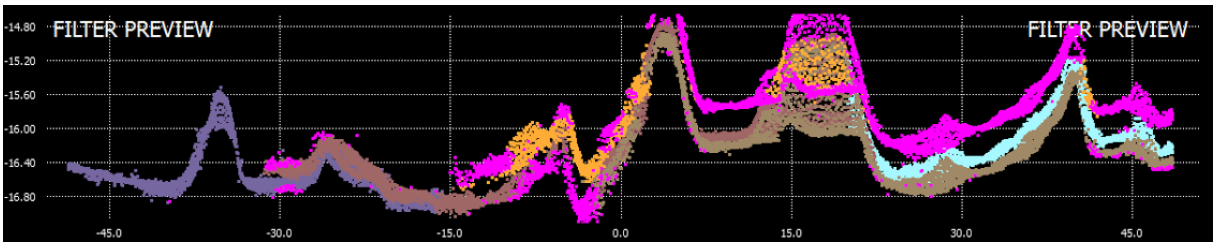


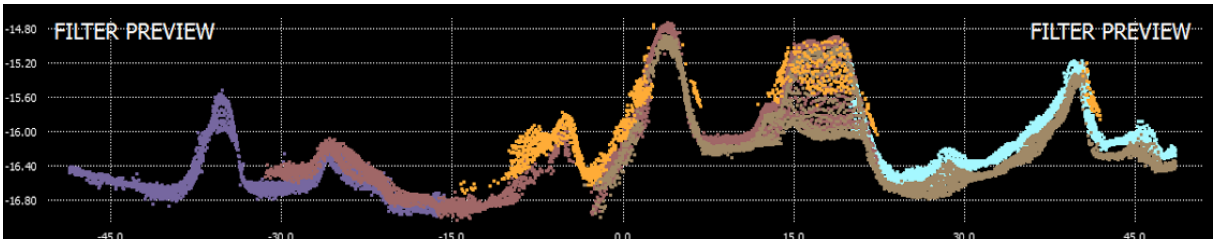
In the third example there is one line that had an RTK problem. The line with the RTK problem is the orange line and is not in line with the other lines.

Before filters



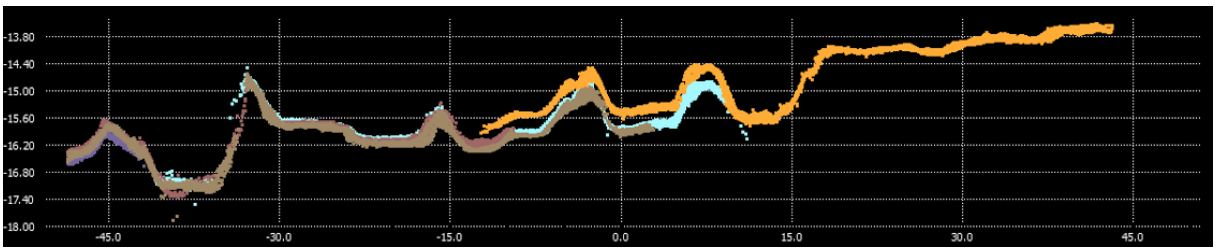
After filters



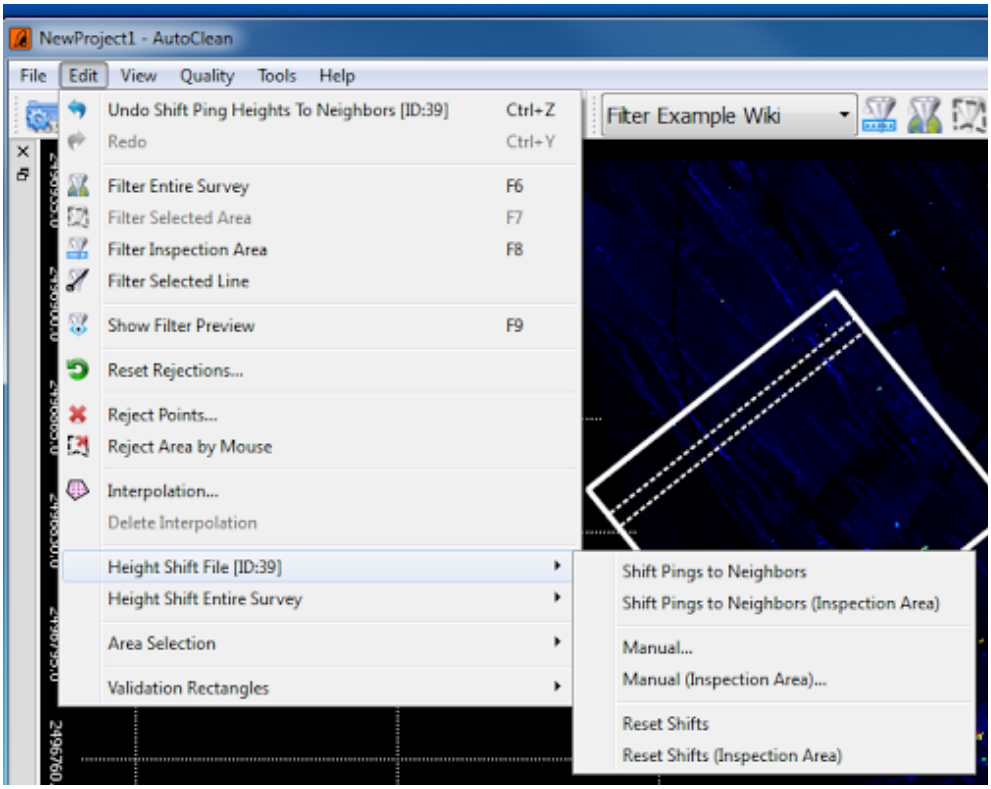


The program will also filter out good data and not only the orange line.

To fix this without the filter you first need to be sure which line has the RTK problems. In the picture below is a different position shown but still the orange line isn't in line with the other lines. The orange line is certainly the line with the RTK problem.



To get the orange line on the same line as the others, you can select that line and choose 'Shift Pings to Neighbors'. This is actually sort of a trick to make the data look good, so to be even more sure the data is correct you should sail another line over this area, or when you have already done that and there is enough overlay the whole line can be deleted.



After this the data will look like this:

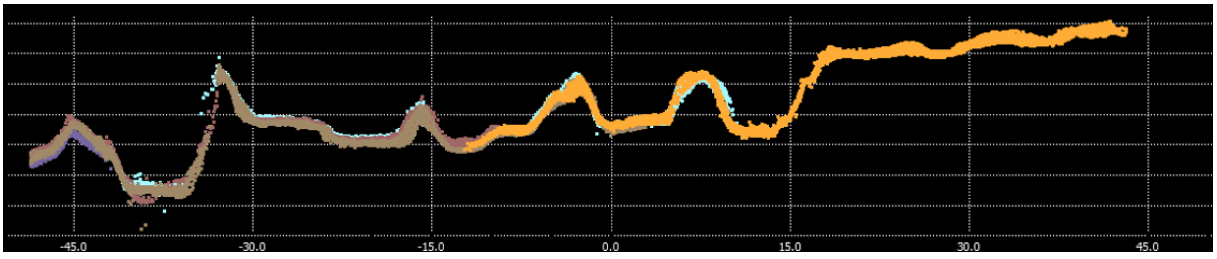


Image 20-49 Survey data with examples of filters

If there isn't anything else wrong with the data, the rest of the filters can now be applied.

5 EPILOGUE

At school we already learned a little bit about data processing but with programs like Qinsy and GRASS. Therefor it was very interesting to work with a new program. I understood how the program worked pretty fast and I found that AutoClean is very client-friendly program. It was easy to work with and is very conveniently arranged.
I had to use this program almost every day so after a while I knew how AutoClean worked pretty good and the processing went quicker every day.

This subject attracts me very, but I found it hard what to put in the report and what not. There are so many options and filters in AutoClean, but I think I picked the most important things in terms of filtering the data in general and at this project.

Overall I think a learned a lot by making this report.

6 SOURCES

http://beamworx.com/autoclean
Surveywiki – Jan de Nul
Simon Steels – Surveyor at site
Autoclean help
http://www.sssi.org.au/userfiles/docs/Hydrography/documents_14755360201084877588.pdf